Chapter 13
New Technologies and ITS for Rail

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13.1 Introduction to ITS

The technical progress has a huge influence in promoting new solutions and concepts and the transport market is facing a new era. This era is defined by ITS and new technologies applied in the transport sector and the increase in efficiency.

Before discussing the usage of Intelligent Transport Solutions in the transport industry it is important to define what can be known as an ITS. The definition of ITS is "Intelligent Transport Systems: These are applications of electronics, IT and communication technologies in the field of transport, that result in the increase of efficiency and the reduction of negative effects from the transport system (pollution, waste time, accidents, etc.)". From this definition, it is important to note that ITS and their applications are very much multidisciplinary approaches involving electronics, IT and communication technologies, computer science, artificial intelligence, social sciences and psychology to name just few areas (the technical and operational requests of infrastructure operators and drivers are fundamental during the design phase of the system).

The integration of Intelligent Transport Solutions among the transport systems is one of the biggest challenges for their implementation. This integration has two main directions: the integration of transport modes (multimodal transport system, multimodal interchanges, etc.) and the integration of information (this will be included services and businesses). These integration could be done based on the common architecture of the transport system which will include not only the traditional component of transport systems (as vehicles and infrastructures are) but

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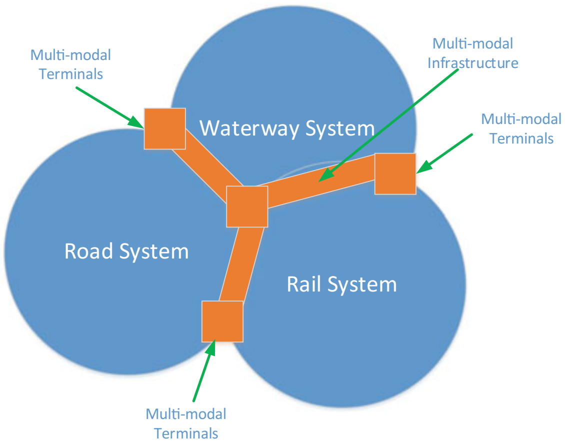
Fig. 13.1 The integration of transport modes/systems



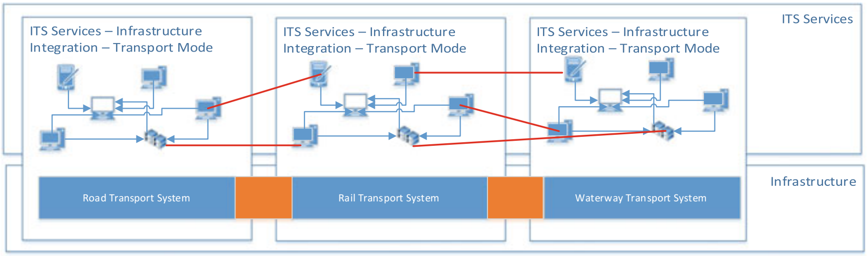


Fig. 13.2 Horizontal and vertical integration of transport modes

also new elements like intelligent infrastructure, smart interfaces, etc. (Nemtanu and Minea 2005; Schlingensiepen et al. 2015).

ITS are specific to all transport modes (road, rail, waterway, etc.) and it is important to consider their uses in transport based on a single system view Fig. 13.1, an integrated view (ITS for multimodal transport systems). ITS also play many different roles in transport systems for example in rail transport, ITS for operation, maintenance, information, management, asset management and so on Fig. 13.2. Management, operation and traveller information are services provided by intelligent transport services. Intelligent transport solutions also assist with aspects of safety and vary considerably in their geographic coverage with some solutions covering local transport and others covering regional or national areas depending upon their design.

Some solutions are fully automated and some are partly automated. From this brief discussion around the variety of solutions, Intelligent Transport Solutions are incredibly wide ranging in both their coverage and fields of application.

The development of ITS starts with a network of sensors which can collect data from transport processes and related phenomena Fig. 13.3. All collected data are

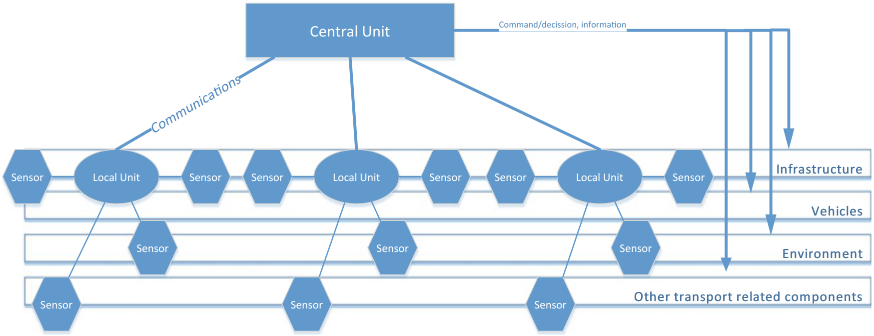


Fig. 13.3 The main components of a generic ITS

transmitted to a centre, using the communication system, which processes all data in terms of supporting transport decision-making process and information systems.

The authors presented the use of ITS on the Road and on Inland Waterways as examples for Rail applications and the starting point for integration and combination of different transport modes.

13.2 Digital Railway

ITS for railway will pave the way for digital railway. Digital railway could be defined as the effect of digitalisation of rail operations and processes in terms of increasing the efficiency of railway sector and to facilitate multimodality approach of transport system to improve the mobility (at vary levels: continental, national, regional or urban). The first step in digitalisation of railway was done through the new electronic interlocking systems and ERTMS (Franklin et al. 2013).

The main advantages of digital railway are as follows:

- Increasing the capacity of the railway network (more trains);
- Better railway connections—integration inside of transport modes;
- Facilitating multimodality;
- Increasing the reliability;
- Decreasing the costs.

The main barriers in the development of digital railway are as follows:

- The shortage of professionals and skilled staff;
- The digital security issue;
- Initial investment costs;
- The lack of multimodal approach of transport digitalisation.

The following paragraphs will describe some new technological concepts which can support and accelerate the digitalisation of railway sector as part of a digital transport system.

13.3 ITS for Road and Inland Waterways

Intelligent Transport Systems concept was defined for road transport in the first place and afterwards the concept was extended for all transport modes. From rail transport perspective, it is important to understand the applications of ITS for road transport to find new solutions for rail transport as well as to find solution for multimodal transport system Road–Rail. There are numerous examples of the application of ITS on the roads. These can briefly be split into two categories, urban and interurban.

Urban ITS—uses of ITS in urban settings include Urban Traffic Control (traffic management, travel time information, air quality, multimodal integration and law enforcement), Public transport management (ticketing, traveller information) and Park and Ride. This urban ITS could be considered for both road and rail transport systems and the integration could be facilitated by the implementation of intelligent transport solutions in both transport systems. The recommendation of the authors is to integrate transport systems at the beginning (in the design phase) in terms of facilitating multimodal approaches. Urban ITS are also important in terms of transport terminals and the ITS supporting terminals and the movement of freight and passengers from one transport mode to another one Fig. 13.4.

Interurban ITS—use of ITS in interurban settings includes Traffic Management Centre’s (traffic management, travel time information, incident management), sensor networks, information provision, communications and freight and logistics (Road user charging, intelligent truck parking, abnormal freight transport). Rolling motorway or highway could be a good example of integration between road and rail transport systems. For this kind of combined transport systems, the most important thing is the efficiency in terms of time (the duration of the trip using two or more

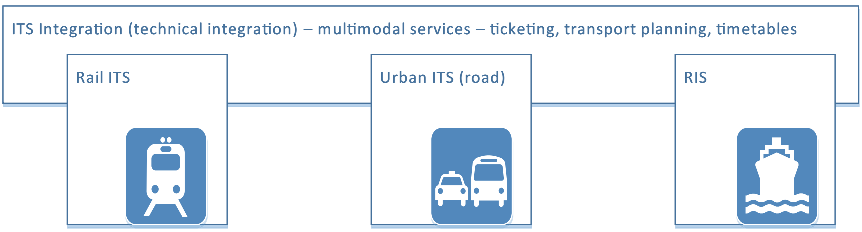


Fig. 13.4 Integration of transport modes in urban area (technical integration)

transport modes) and the cost (total cost of the transport for A to B, for both/all transport modes involved).

ITS are also used frequently on Inland Waterways with RIS (River Information Services) being the main example of utilisation of ITS on Inland Waterways. These services are defined as "modern traffic management systems enhancing a swift electronic data transfer between water and shore through in-advance and real-time exchange of information". This shows that other transport modes are already using ITS in everyday operations. This discussion will now move onto the use of ITS in rail and potential developments in the future. RIS are mainly developed to provide information services to all ships (inland water ways, maritime and the transition between rivers and seas), and it is a good example and a best practice to be applied in Rail systems as well as to integrate these solutions with solutions from other transport modes.

13.4 ITS for Rail

Railway Companies have already used a considerable amount of ITS in their network. Some traveller information services and ticketing systems use ITS. However, the largest current utilisations of ITS in the rail system are interlocking (Fig. 13.5) and the European Railway Traffic Management System (ERTMS). All the uses of ITS in rail are safety orientated; safety is inevitably the main aim of any innovation in Rail. For example, most ITS have safety fail safes in case of failure built in or feature a 2 out of 3, computer interlocking system. The ITS for rail systems started a lot of time ago with interlocking, signalling, train protection and other applications of electronics in railway transport systems.

The track circuit is considered the main sensor of the interlocking system is in charge to detect the presence of the train on a specific track part where the circuit is

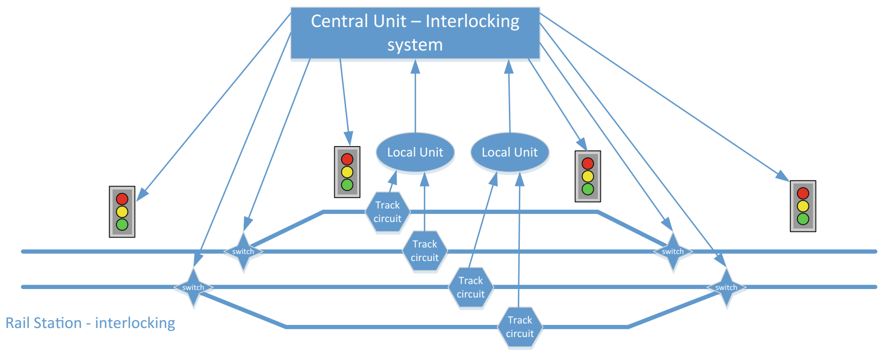


Fig. 13.5 Simplified structure of an interlocking solution (based on Fig. 13.3 The main components of a generic ITS)

installed (Franklin et al. 2013). Central unit collects the data related to the presence of the train and makes decision about the route, the direction and the speed of the trains around the station. The decision is applied using signals and switches. This is a universal structure for ITS based on the network of sensors, communications and data processing units.

The track circuit is considered the main sensor at this moment and will be replaced by new technologies like GNSS and ERTMS. The main role of the track circuit is to ensure the train detection and the information of available railway resources (in this case free tracks which will be included in the new routes).

The principle of the track circuit as well as the role of it in railway system will be implemented using new technologies. The main aspect is to provide information about the availability of the track as well as the integrity of the trains.

The principle of a track circuit is to build an electrical circuit with an emitter, a receiver and a pair of wires (the rails are used as wires). The emitter will transmit an electrical signal (the voltage UE in Fig. 13.6) to the receiver (the voltage UR) based on pair of wires. If the signal is received by the receiver the track section is free (the absence of the train). If the signal is not received by the receiver, the train is passing this section and the section is not able to be used by another train. Another important role of the track circuit is to check the integrity of the rails (if the rail is broken, the "wire" is broken and the receiver will not receive any signal; this case is similar with a track section occupied by a train—Fail Safe approach). The integrity and the functionality of the track circuit are also checked by track circuit itself (if the emitter is turn off the receiver will consider the track occupied by a train and will send this information to a specific signal and the signal will display RED).

The track circuit is the main sensor and the principle of the functionality of this circuit could be implemented based on new technologies. Three main conditions should be taken into consideration when a sensor is replaced with another one: the new one must be more reliable (the mean time to failure MTTF must be increased), the new sensor should be at least at the same level of safety as the replaced sensor is, and the cost of introducing the new sensor should be lower than the cost of the previous one.

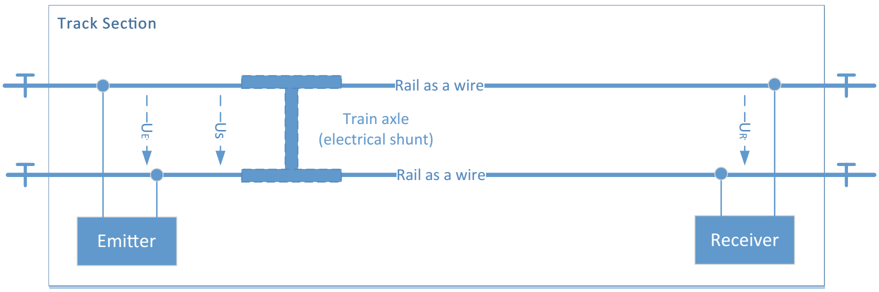


Fig. 13.6 Track circuit (principle)

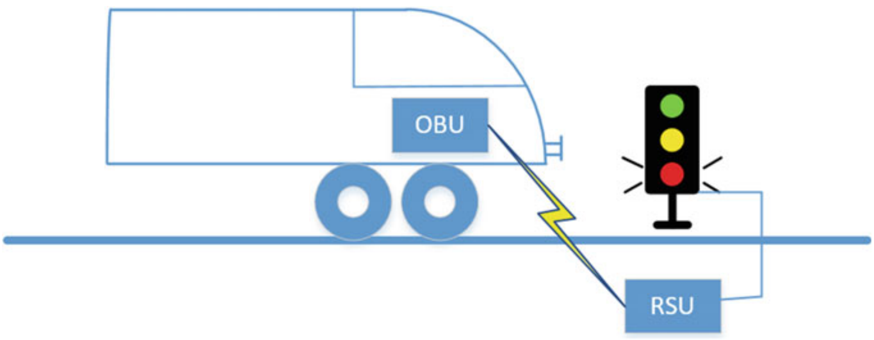


Fig. 13.7 Train protection

The train protection is important to avoid the presence of two trains on the same track section. This train protection could be done using two principles: based on fix track circuit with the detection of the train on a fix track section and based on virtual or moving track section (moving block)—the section will be defined as a virtual section and if the distance between trains is going under a safety limit the train protection will act the breaks of the train.

In Fig. 13.7 is presented the first principle (this is used at this moment on majority railway networks) and this is based on the existence of two main components: RSU (Rail Side Unit; in ERTMS this component is called LEU—Lineside Electronics Unit) this is installed on rail side and has the main functions to collect information from the signal and to send this information to the train (OBU) and OBU (On-Board Unit)—this is installed on the board of the train and has the main functions to receive information from the RSU and to stop the train (if the situation asks this—the train is passing a RED signal).

13.5 ERTMS

European Railway Traffic Management System is a new concept and all European countries (not only European countries, Australia has a good trend in developing this system) are working to implement this system and to mitigate their system to this new concept (EC 2016; UNIFE 2016).

The ERTMS is a major example of the use of ITS in rail and a good example in terms of applying the standards in ITS. It has two main components:

- ETCS—European Train Control System: movement authorities, train protection, signalling
- GSM-R—Global System for Mobile Communication—Railway—this system is similar with GSM but is more oriented on railway transport and its constrictions, especially related to safety problem (UIC 2016).

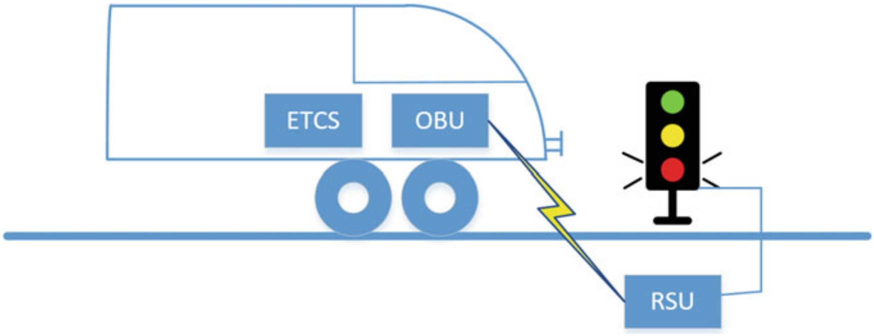


Fig. 13.8 ETCS level 0

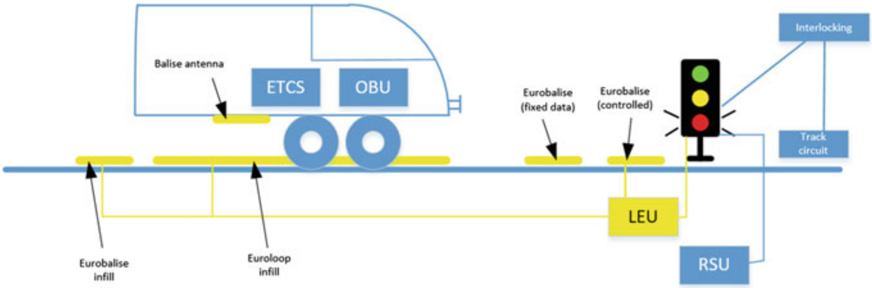


Fig. 13.9 ETCS level 1

ETCS is specified at four different main levels:

- Level 0: ETCS-compliant locomotives or rolling stock interact with lineside equipment that is non-ETCS compliant, Fig. 13.8. Level 0 is a transition step from existing interlocking and signalling system to ERTMS (this step is focused on trains and rolling stock).
  ETCS level 0 is the case of trains equipped with ETCS which are passing the railway network without any ETCS implementation. This step is present at the migration from actual state of development to ETCS-compliant railway network. This level is a consequence of multistep implementation of ETCS and the fact that the trains must to be able to pass all types of railway sections.
- Level 1: ETCS is installed on lineside (possibly superimposed with legacy systems) and on board; spot transmission of data from track to train via ETCS balises, Fig. 13.9. The system can manage both trains, with and without ETCS on board.
  This level is also important for migration to ETCS. The legacy systems are interfaced with ETCS-compliant trains and ETCS is working in parallel with the existing systems. The data is transmitted only in spots.

- Level 2: Same as level 1, but ETCS data transmission is continuous; the currently used data carrier is GSM-R, Fig. 13.10.
  Another component of ERTMS is involved in this level, GSM-R. GSM-R is a mobile communication network which is similar with GSM but it is adapted to safety conditions and the context of railway transport system. Radio Block Centre (RBC) is in charge with the movement of trains and the communication support is provided by GSM-R. There are also Eurobalises but, their role is only for position calibration. The transmission of data is continuous; there is a permanent communication link between the trains and the RBC or lineside equipment. Track circuit and other trackside sensor are the main components to detect the position of the train (as well as the integrity of the train.
- Level 3: Same as level 2, but train location and train integrity supervision no longer rely on trackside equipment such as track circuits or axle counters, Fig. 13.11.
  The level 3 is similar with level 2 but the position of the train is detected by the train itself (as well as the integrity of the train). These functions are very important because the RBC must establish a reliable communication link with the train to receive the position and the integrity information from the train.

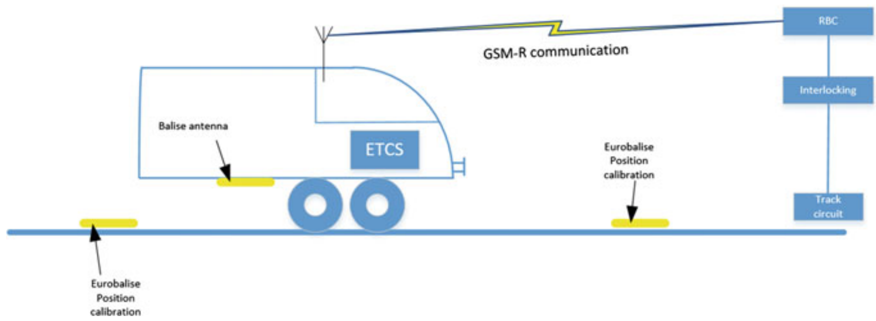


Fig. 13.10 ETCS level 2

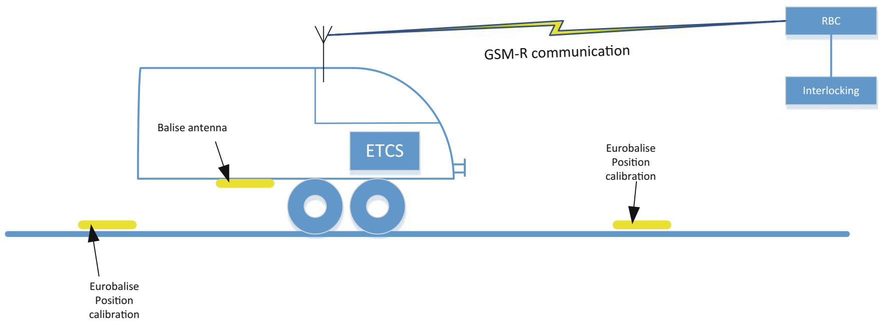


Fig. 13.11 ETCS level 3

13.6 Smart Mobility

Smart mobility is a key concept for the future. Smart mobility refers not only to the transport of people and goods but to mobility of people and goods as a high-level service. Smart mobility is also one of the six main components of a "smart" city, Fig. 13.12: mobility, people, economy, governance, environment and living (TU—Wien 2014; Nemtanu et al. 2016a, b). Mobility is defined as the ability to move or be moved freely or easily. Smart mobility has two main components: the smart technological system which will provide support for implementing the smart mobility and the smart approach of smart mobility as integrated part of a smart city (based on this approach the smart mobility is integrated will all components of a smart city).

ITS for all transport modes is the support system which can provide services having as objective the implementation of smart mobility in urban area.

The smart mobility as a component of a smart city should relate to all smart components of this type of city (this is the external view point on smart mobility). Smart mobility should strongly relate to smart economy, mobility services are part of this smart economy and the capital and market resources should be involved in the development of smart mobility. Smart people is another important component, human beings are involved in mobility not only as users or passengers but also as operators, staff and administrators (smart mobility should facilitate the smartness of people through increasing the accessibility as well as the access of people to a wide area of urban resources).

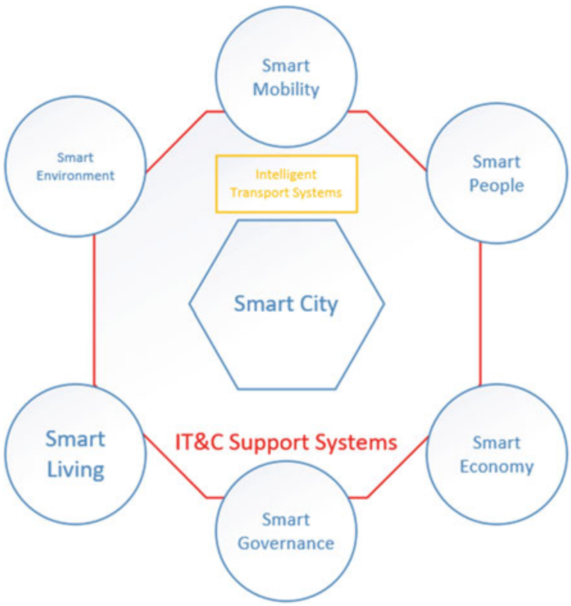


Fig. 13.12 The components of a smart city

Smart governance is also involved in smart mobility in terms of leading the mobility activities and the mobility as part of the urban system. Transport systems and mobility services for people and goods have a strong impact on the environment. The smart environment approach should integrate all urban subsystems in a single concept and should decide for all components of the urban system. Smart living is mainly a result of all components and the quality of life could be measured in urban area based on several key indicators, the mobility and the accessibility are mainly the indicators which could affect the quality of life and smart living in the city.

Another view point on smart mobility is internal one, on the components of the mobility system which is in charge with the provision of smart mobility. This mobility system is manly formed by urban transport system and it must include all transport modes. The integration of these transport modes is also a measure of the smartness of the mobility in urban area and this aspect relates to all components of a smart city, Fig. 13.13.

The smart city is based on IT&C support systems for all components. Intelligent Transport Systems could be considered as part of these support systems. There are two main approach of the integration of different components:

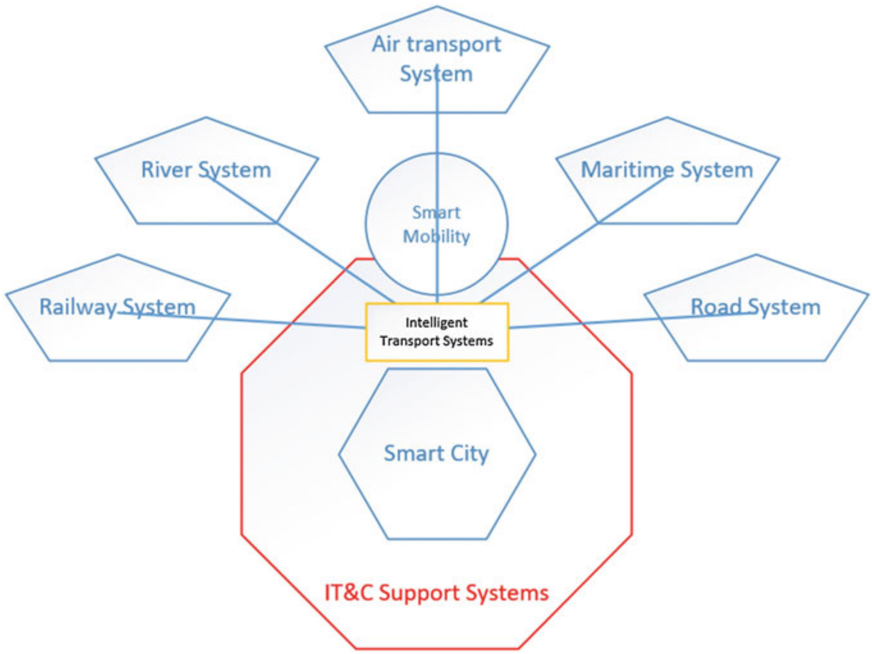


Fig. 13.13 Smart mobility and integrated transport system

- The integration of ITS components from all transport modes—the main scope is to have an integrated ITS for integrated or multimodal transport systems.
- The integration of ITS with all IT&C support systems—the objective is to have an integrated smart city support systems for all six components.

13.7 Mobility as a Service

Recent moves have been made towards Mobility-as-a-Service (MaaS) which is a concept related closely to the smart city approach [9]. MaaS describes a shift away from personally owned modes of transport and towards mobility solutions that are consumed as a service. This is enabled by combining transport services from public and private transport providers through a unified gateway that creates and manages the trip which users can pay for with a single account. Users can pay per trip or a monthly fee for a limited distance. New European initiatives such as MaaS Finland, ERTICO ITS Europe and Maas Alliance have attempted to implement this system in real life, Fig. 13.14.

Intelligent Transport Systems are defined as middleware in this new concept of Mobility as a Service and the main role is to collect information from all transport modes, included railway, and to provide ITS services for MaaS applications and systems (Nemtanu 2014; Nemtanu et al. 2016). Mobility as a Service is a service of

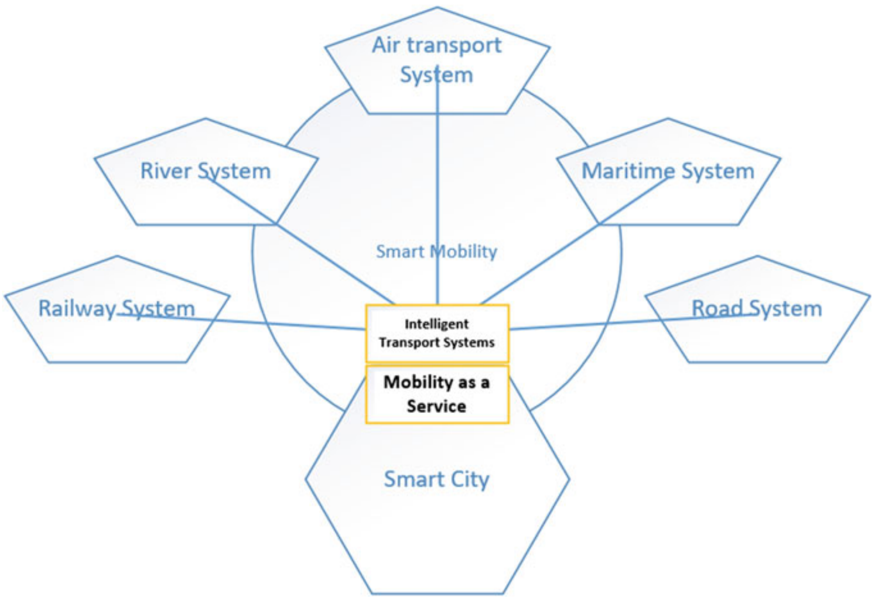


Fig. 13.14 MaaS and smart mobility/smart city (ITS as middleware)

smart mobility in a smart city. Railway operators could have a main role in the development of MaaS through the involvement as MaaS operator and the MaaS support system could be developed around railway infrastructure and systems. Railway public transport could be considered as a backbone for MaaS, especially for conurbation and metropolitan areas.

13.8 Cloudification

The advent of cloud computing also provides opportunities for the transport industry. It provides access to all services at any time without the necessary direct link with hardware that was previously needed. It allows users of software to use a virtual computer and not a physical computer (as well as other virtual resources, storage, etc.). You can now use software online (Microsoft Office) and even use the cloud for data storage. The cloudification of logistics is a good study case of this process (Nemtanu et al. 2015), Fig. 13.15. That means the support of logistics processes is provided by applications and systems from cloud. However, a disadvantage in this development is potential lack of physical access to hardware which is not along with the user of the cloud services. Advantages though, include price (of virtual machines) and access to all types of services through the web. The cloudification of railway transport will facilitate the access of all passengers to railway transport services (Pacheco et al. 2016) and will pave the way for MaaS and other new approaches related to the mobility of people and goods.

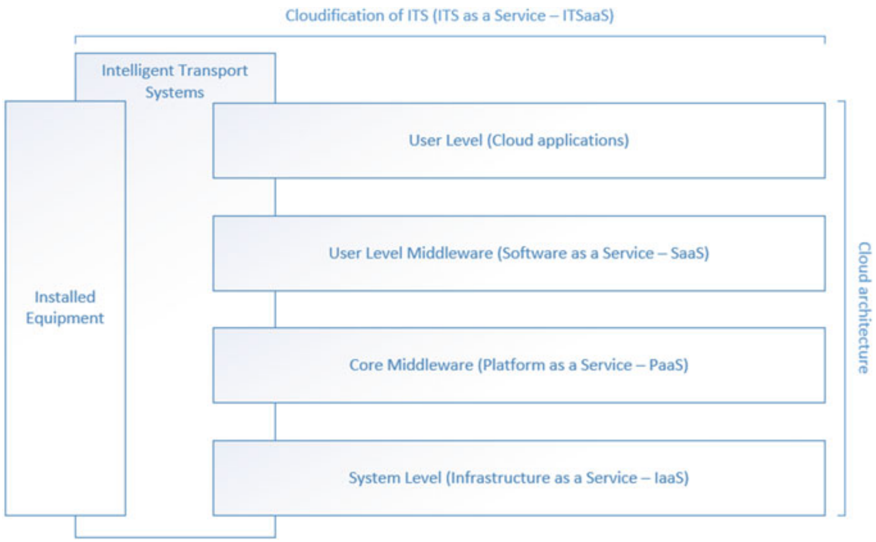


Fig. 13.15 Cloudification of ITS

ITS for all transport modes have two components: installed equipment which is basely the existing systems and some components in cloud (the cloudified components are more accessible in terms of cost and time). Based on the figure which is showing the cloudification of ITS, the concept of ITS as a Service could be also defined as ITS Services which are available without any infrastructure development from the user side and which are working in the same manner as a physical system. Railway systems could be also developed in cloud and new approaches and methods of ensuring the safety level could be implemented to support this.

13.9 Gamification

Gamification is defined as "the application of typical elements of game playing (e.g. point scoring, competition with others, and rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service". In this case, the transport domain is the product or service. Objectives can include adaptation and more effective human–machine interaction, increased awareness and eco-driving. For example, drivers of any vehicle linked to this service can be rated on their eco-driving level with scores uploaded to a server. They can then be ranked based on scores and there is the potential to reward those who rank highest. In the case of eco-driving it also offers railway operators a means to assess each driver's performance and target retraining appropriately to those drivers who are not driving efficiently.

The gamification is using the game related techniques and methods in non-gaming systems to improve user experience and user engagement (the main objective is to improve the efficiency and the productivity of the system where user is involved) (Deterding et al. 2011).

Gamification is the application of game elements and digital game design techniques to non-game problems, such as business and social impact challenges, Fig. 13.16.

The main role of gamification in railway systems as well as in any other transport systems is to optimise the activities and processes where human beings are involved. Based on similar approaches like games have, gamification of railway system will introduce new components in Human–Machine Interface (HMI) which will increase the efficiency of the system. The main implementation of gamification in transport system is, at this moment, in eco-driving (the drivers are playing a game during their driving activity and the main objective is to reduce the consumption and the environmental impact of their vehicles).

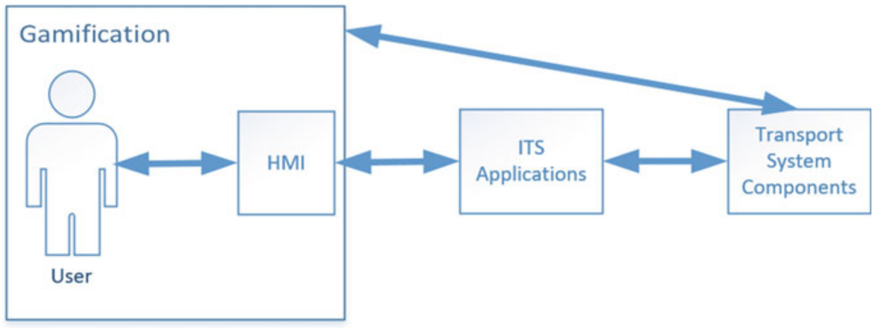


Fig. 13.16 Gamification in transport systems

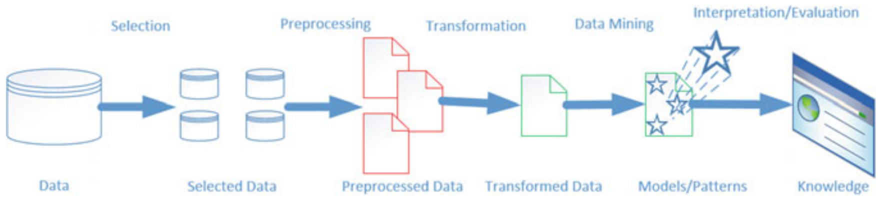


Fig. 13.17 Data mining process (based on data (Fayyad et al. 1996))

13.10 Data Mining

Data mining refers to an improved method of data collection, involving huge volumes of data being collected. The process then searches for patterns, relations and correlation within the data. The process of data mining has the following components:

- Selection of data from data sources in terms of defining the data base for data mining—databases, flat files, newswire feeds, etc.
- Preprocess data—collect data and specific data (it depends of the user's requests), clean data and store data
- Transformation of data in a format which is suitable for data mining methods and techniques.
- Search for patterns or models and relations between data—queries, rules, statistics, etc.
- Interpretation and evaluation of the results—this is most important to underline the role of data mining

Data mining turns a large collection of data into knowledge and this new domain of data processing and manipulation was possible due the evolution and progress of information technologies and computer science (Han et al. 2012), Fig. 13.17.

Data mining is and could be used in railway systems as well as in any other transport systems. The data collected by sensors from tracks, trains and other railway components will be processed based on the process presented in Fig. 13.17, and the results of applying this process is to find some new links between existing data. One example of applying data mining is to find a relation between the failure of the communication systems of the railway interlocking system and the frequency of the maintenance activities on these systems.

13.11 Big Data

In big data, the number of sensors is increased, with various new data sources with interfaces between them leading to a process of data exchange. For example, in Road ITS, a variety of sensors are taking measurements every few seconds about traffic, etc. The volumes of data that are collected in the world every day is inestimable and therefore big data and data mining must operate concurrently so this huge volume of data can be efficiently used, Fig. 13.18. Behind this huge volume of data, a lot of different relations and correlations exists and all of them could be used to increase the efficiency of transport systems as well as the efficiency and the impact of ITS systems implemented and installed in railway systems.

In railway transport, every installed system as well as all components which can manipulate data could be a source for digital data. All these sources of data will provide a huge volume of data and there is a strong request for manipulating and processing them (the data could be unstructured or structured, it depends on the

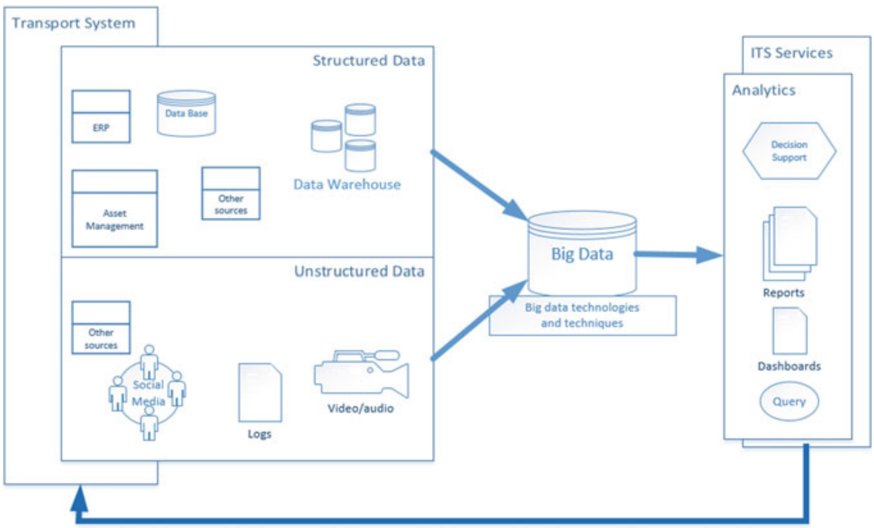


Fig. 13.18 Big data and ITS

source of data). This is the domain of big data and the solution is to use big data techniques and technologies to increase the level of services through accurate and reliable data and information as well as a quick response in time (real-time information). The big data concept has three main characteristics (3Vs): volume, variety and velocity. All these characteristics (the big data) will affect the way to take the decision in railway transport as well as in all transport systems. The prediction of the evolution of transport and traffic processes could be done based on big data solutions (Lv et al. 2014). The usage of big data in public transport was already done in several countries and in (Oort and Cats 2015) is presented the case of Sweden and Netherlands.

13.12 Network of Sensors

This refers to various new sensors being installed often "smart" sensors or sensors with connectivity. For example, modern smartphones can be classified as complex sensors. Smart sensors must be linked together in a huge network such as Google which uses the public's smartphones as sensors relating to traffic. The main role of the network (network of sensors) is to collect real-time data from various processes and phenomena in terms of supporting the decision-making process in transport activity.

The network of sensors could be expended by virtualisation and virtualised sensors could be used in other applications, in this case for railway transport systems, Fig. 13.19. ITS for rail could work based on the sensors installed along the trackside and railway transport system components but also based on virtual sensor network which will provide data from various sensor without any direct connection to these sensors.

A well-known multimodal safety system is road–rail crossing signalling system which is based on rail sensors (for the detection of the trains) and which commands road traffic signals based on the information collected by rail sensors. These rail sensors could be integrated in a network of sensors and the information collected by them could be available for any other ITS applications and the railway system could play as a virtualisation service provider and could send the information from the sensors, as information from virtual sensors to any other railway system and transport system.

Application of wireless sensor network in vehicle location has already demonstrates that the sensor networks have multiple and wide application areas and they are suitable also for railway systems and applications (Postigo-Malaga et al. 2016).

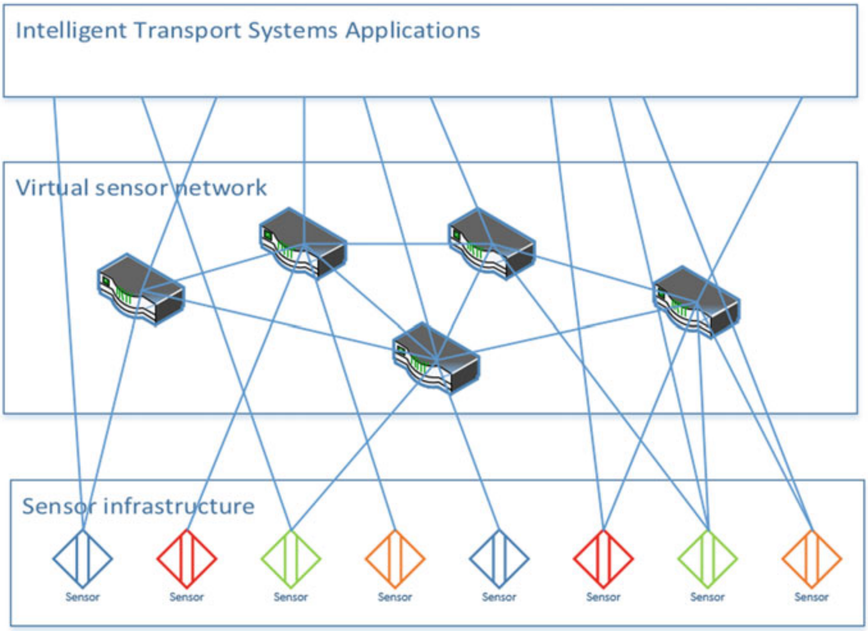


Fig. 13.19 Network of sensors

13.13 Internet of Things

The Internet of things is defined as "a development of the Internet, in which everyday objects have network connectivity, allowing them to send and receive data" (Buyya and Dastjerdi 2016; McEwen and Cassimally 2013; Chaouchi 2013), Fig. 13.20. For example, even objects such as refrigerators and washing machines are often now Internet enabled to increase connectivity. Such a development would have been unthinkable only a decade ago. Every component of the rail infrastructure or rolling stock will be able to establish an Internet connection and to exchange data with other similar components and the new concept will generate new approaches and solutions in terms of safety, environment protection and sustainability.

Every component of the railway infrastructure (for instance, signals) should be able to be connected to the Internet and communicate with other entities about the state or the functionality (a connection between the signal and the maintenance company will provide information about the state of the signal and the need for maintenance intervention).

The IoT is defined by connected devices (sometimes with embedded intelligence) the role of this devices is to collect data and to send this data over the Internet (using the communication systems). Next step is to do data analytics (Artificial Intelligence, Big Data, etc.) to find values for all data collected. The data

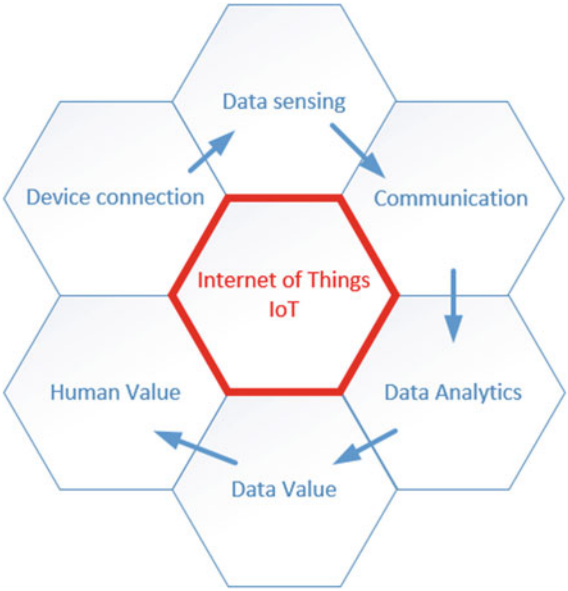


Fig. 13.20 Internet of Things—Value chain (based on (i-Scoop 2016))

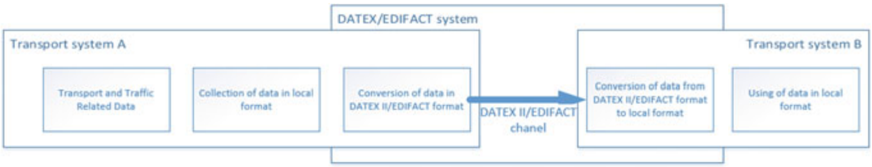


Fig. 13.21 DATEX II/EDIFACT systems

value should be transformed into the human value. This chain should be applied also in railway transport, all railway related elements should be integrated in IoT to provide human value for these applications (some examples could be: safety, efficiency, cost effective, etc.).

13.14 Data Exchange

Data exchange refers to the exchange of data between systems in the same domain and the exchange of data between systems from different domains. The main challenge is to find a common understanding for data when the sender and the receiver have different data systems. The main solution is to find an intermediate language and to translate from one data system to another one.

The EDIFACT standard provides (Krathu et al. 2013; Janner et al. 2006), Fig. 13.21:

- A set of syntax rules to structure data
- An interactive exchange protocol (I-EDI)
- Standard messages which allow multicounty and multi-industry exchange.

DATEX 2 provides an alternative standard and model for data exchange. This is a good example of the application of standards in transport (road transport) and the effect is to pave the way for integration of different systems as well as the interoperability between systems, subsystems and modules (Wei-feng et al. 2008; Raines and Rowley 2008).

DATEX II is an example of using XML in data exchange solutions for road transport system. This example could be used also in railway system, the model of implementation should be the same.

After the implementation of ETCS level 3, no track circuit or trackside sensor will be installed and the presence of the train on a specific railway section must be sent by train to RBC (Radio Block Centre) but also to other transport modes where this information is relevant. The solution should be a XML implementation similar with DATEX II.

13.15 Implementation

As seen in the previous paragraphs, new technology helps to maximise utilisation and make the best from the current infrastructure in terms of providing better (e.g. faster, more punctual, etc.) services with a limited need of investments. From the perspective of the users this might not be enough to accept the big amount of private data collected in the systems. And from the perspective of the stakeholder in the transport system that makes investment in these new technologies uncomely. Thus, an approach doing the integration of systems step-by-step with focus on the user's demands is needed. The main benefit for the users must be that the systems are not only self-aware, but aware of the user and his needs. An example can be travel assistance, that does not only follow general optimization strategies like minimising time and cost, but also take in count users habits or health constraints, like it was shown with a personal travel assistance that takes account of users with mental or physical disabilities (Schlingensiepen et al. 2015a, b) or the approach of "smelly roads" that finds optimal walking routes, not only in terms of the shortest path, but also on terms of nice surroundings (Quercia et al. 2014). Thus, principles were defined in (Doyle Cottrill et al. 2016) as situation aware systems integration a term that describes the integration or interaction between different stakeholders in a system to fulfil a practical purpose that allows to justify investments of money and divulgation of privacy.

Since there is a good change, the full integration respective to centralization of all functions and data will fail because of the high complexity, the authors propose to following this approach: The integration of systems starts with integration of data for a given use case, this shall be done by enhancing department-to-department

(D2D) cooperation and coordination, via improved D2D communication and data exchange, through a common formal semantic vocabulary. So, each stakeholder shall use its own well-known sensors, models and data enriched by information provided by other parties. Since transportation is a main function, the authors already mention it as an example: Transport, energy generation and construction are three “departments” within a City that manage functions which generate urban emissions as a side effect. Currently there is no (as far we know) communication or coordinating control between them. It is well known that cities regularly break air pollution limits, even in Europe. It may be possible for “Transport” to adjust regional traffic flows to alleviate this pollution, but this takes no account of the other ca. 50% of pollution which is generated by other utilities. Currently it is not known how these departments can communicate and combine together to produce a holistic solution to the problem. In fact, there is likely to be little shared knowledge between them. Enabling D2D communication on a shared vocabulary, could significantly tackle this challenge.

This examples show how the new technology shown in this chapter can be utilised in real life without premise the full integration of all services in a so-called smart city. The challenge we are facing today is to identify the practical use cases that allow step-by-step integration and provide user benefits for each step. Since the investments in rail are very big and so the time span to return on investment is very long this is much needed. As seen in the example of ERTMS the standard itself is quite old but the progress is still limited to dedicated routes, where a use case like connecting industrial areas or implementing a green transit was identified and addressed by railway companies, politics and costumers.

13.16 Conclusions

This chapter has shown the widespread use of ITS in road, inland waterway and rail businesses and discussed the possibility to integrate all transport modes based on intelligent transport systems as middleware. New and developing technologies could make the use of ITS even more widespread.

New sensors could lead to a virtual track circuit, new technologies for communication (such as more advanced GSM-R) could assist communication across the rail network and the development of new approaches (mobility as a service, cloud services, big data and data mining) could provide new opportunities and innovation in rail and will pave the way for new applications and the development of smart way to solve the problem of mobility. New services based around Wi-Fi and real-time information can also be developed.

More research around the potential ITS innovations and their usage must be conducted to benefit the wider rail industry and create more value resulting from these new solutions. These can then hopefully become solutions whose benefits outweigh their costs.

In the future, there will be new support technologies for mobility and transport and new approaches. These will fit into new designs for transport systems which will be radically redesigned to allow inclusion of new technology. This will allow connected vehicles, people and things and give everyone access to information. This will provide access to potential new markets. The railway transport will be a main part of new smart transport systems (one example is Mobility as a Service). This requests new concepts and models. The integration of all components as well as the integration of all transport modes in a single transport system that provides support for mobility in a smart manner is key for a sustainable development of transport.

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